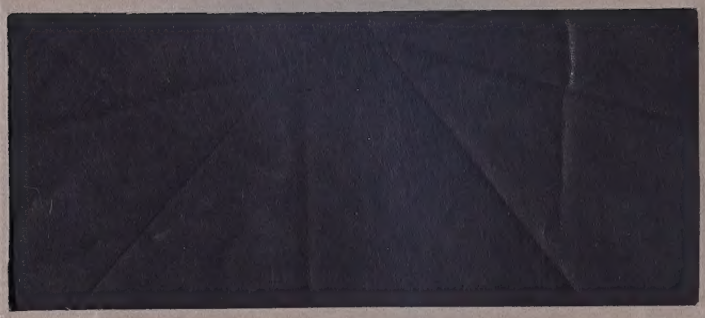
Sperry Microline

CROSS-GUIDE DIRECTIONAL COUPLER

Model 419 Ser.#10

SPERRY GYROSCOPE COMPANY
DIVISION OF THE SPERRY CORPORATION
GREAT NECK, NEW YORK



MICROLINE

CROSS-GUIDE DIRECTIONAL COUPLER

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OPERATING INSTRUCTIONS
AND
TECHNICAL DATA

SPERRY GYROSCOPE COMPANY
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PUBLICATION NO. 23-1811D JANUARY 1954

OPERATING INSTRUCTIONS
AND TECHNICAL DATA

Microline®

CROSS-GUIDE DIRECTIONAL COUPLERS

MODELS
306, 544, 545, 233, 321, 322, 209, 237, 305, 546, 547, 234, 235, 419, 388, 413A, 414A, 415 and 405A
2.6 to 36.0 KMC

The cross-guide directional coupler design produces high directivity and an unusually uniform coupling characteristic over the full frequency range of each waveguide size represented in the group. Because of the rugged fixed-tuned construction built into these instruments, the calibration stability inherent in this type of coupler will remain constant under all conditions of normal use. Temperature and humidity effects are negligible. The Microline models included in the group provide continuous coverage for microwave measurements at all signal frequencies from 2.60 to 36.00 kilomegacycles per second (kmc).

APPLICATIONS

Microline cross-guide directional couplers are versatile, precision instruments well adapted for general laboratory use and production test work, or as components in microwave communication and radar systems where it becomes necessary to monitor the signal without disturbing or disconnecting the circuit.

When operated in conjunction with suitable accessory equipment, they are used with c-w, pulse or square-wave input signals for:

(1) measuring absolute power traveling either towards the load (incident power) or towards the signal source (reflected power);

(2) isolating or decoupling microwave components in the measurement or monitoring of signal frequency and power in the main transmission line;

(3) attenuating input power levels by known factors. Microline precision calibrated directional couplers are suitable for use as secondary attenuation standards;

(4) determining voltage standing-wave ratio by measuring the comparative power levels of the incident and reflected waves in the primary line.

DESCRIPTION

The cross-guide directional couplers in this group are rugged, compact instruments requiring no tuning adjustments. They are built to precise tolerances to give approximately uniform electrical performance within the broad frequency band covered in each transmission line size.

All models in this group are built to the same basic design and fabricated in the appropriate rectangular waveguide size corresponding to the particular standard frequency band to be covered. External appearance, therefore, is almost identical throughout with only slight variations occurring as the connector design changes. Internally, however, the dimensions of the coupling irises will be found to vary with the degree of coupling desired, and with the particular transmission line size.

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SPERRY GYROSCOPE COMPANY
DIVISION OF THE SPERRY CORPORATION · EXECUTIVE OFFICES: GREAT NECK, NEW YORK
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The basic design common to all models consists of a cross formed by two short sections of the same size rectangular waveguide. The sections are rigidly joined at right angles at the broad guide surface. The wall of one of the guides is cut away so as to leave a single wall thickness at the junction.

One waveguide section fitted with flange connectors at each end forms the main or "primary" line of the instrument. The other section is fitted with a flange connector at only one end, and is designated as the auxiliary or "secondary" line. The opposite end of the auxiliary line is terminated with a matched load in the form of a tapered length of special resistance card. A shorting plate is permanently mounted beyond the matched load at this end of the waveguide.

In each model, input signal energy is coupled from the main to the auxiliary guide through a pair of apertures located near the diagonally opposite corners of the common junction wall. In any particular waveguide size the shape and orientation of these ireses vary with the specified degree of coupling. In general the aperture area decreases with increasing attenuation.

As an aid to proper connection of the instrument during operation the main waveguide is clearly marked to indicate the normal direction of the load.

GENERAL OPERATION

Cross-guide directional couplers are instruments designed to operate as one-way power monitors in waveguide transmission lines. These devices are responsive to power flowing in only one direction in the main waveguide, and couple a definite fraction of this power to the output terminal of the secondary guide.

In describing the characteristics of directional couplers, there are two useful definitions. Coupling is defined as the ratio of the output power level in the secondary guide to the power level in the main line and is usually expressed in decibels. The term "effective directivity" is the ratio of the secondary guide output power coupled from a unit wave introduced into the normal input (generator) end to that extracted from a unit wave introduced into the normal load end of the primary guide, with the main waveguide perfectly terminated in each case. Directivity is expressed in decibels.

The coupling and directivity obtained in any particular coupler are largely controlled by the design of the coupling apertures. These cross-guide directional couplers are designed for maximum uniformity of coupling and directivity over the useful frequency range of each waveguide size. They also introduce negligible effect on the VSWR of the line in which they are inserted.

The termination in the auxiliary line is necessary to absorb any power coupled from the reflected wave in the main line.

OPERATING PROCEDURES

1. The accuracy of directional coupler measurement of incident wave absolute power is independent of the load impedance and the point of coupler insertion

in the line. However, since the response of the instrument is proportional to the excitation in one direction only (see figure 1A), it does not measure net power absorbed by the load directly unless the load impedance is exactly equal to the characteristic impedance of the line. If the load is mismatched, the indicated power will be in excess of that dissipated in the load by the amount of reflected power. For measurements of true power absorbed by a load, a simple determination of VSWR using an impedance meter will yield a coefficient of reflection from which net power may be computed. The power absorbed by the load may be found by separately measuring the reflected power.

The reflected power level is measured by inverting the cross-guide directional coupler from its normal operating position and connecting the designated load end of the instrument to the signal input. All incident power entering the auxiliary arm will then be absorbed by the termination and the reflected energy coupled from the main line will be directed to the output end of the secondary arm where it can be measured with a suitable bolometer. See figure 1B.

2. Non-dissipative isolation or decoupling of microwave components - such as frequency meters or power detectors - from the main transmission line is provided by the appreciable attenuation (20 db min) between the primary and secondary lines of these instruments. Thus any disturbance introduced into the secondary line of a directional coupler by a frequency meter has minimum reaction upon the primary line of the system. Frequency pulling and power mismatch of the signal generator are greatly reduced and the waste of power inherent in dissipative isolation of a microwave component is eliminated.

3. When calibrated against primary attenuation standards, cross-guide directional couplers serve as excellent fixed-attenuation standards since the coupling is not affected by variation in temperature or humidity. When used in this application it is desirable to terminate the load end of the main line with a matched load. The coupling values of the instrument, as indicated on the curve furnished with each unit, then become its attenuation values at all frequencies over the range.

4. For measurement of microwave receiver sensitivity directional couplers are useful to reduce the power level to a value that will not overload the input stage of the receiver.

5. A pair of directional couplers may be used to measure voltage standing-wave ratios. One coupler operates in the normal position, measuring the incident power; the other is inverted to respond to the reflected power only. The ratio of these measurements equals the square of the reflection coefficient (ρ) of the load:

$$\frac{P_{ref}}{P_{inc}} = |\rho|^2 \text{ and VSWR} = \frac{1 + |\rho|}{1 - |\rho|}$$

CALIBRATION

A characteristic curve of coupling in db vs frequency is provided with each cross-guide directional coupler. The curve represents average values from measurements on couplers of the same model.

The actual measured coupling for each particular instrument is also indicated at three frequency points on the characteristic curve. Calibration points are taken at the mid-frequency and the high and low limits of the range. Coupling at mid-frequency does not differ from the nominal value by more than ±2 db, and there is less than 3 db variation over the band.

The accuracy is ±0.5 db at the measured calibration points for all cross-guide directional couplers in this group.

MAINTENANCE

Directional couplers should be kept clean and handled carefully. The entry of oil, dirt or any foreign material into either line may change the coupling and directivity characteristics and can produce excessive mismatches and high attenuation.

The contact faces of the waveguide flange connectors should be kept clean and free of nicks or burrs which would prevent a tight mechanical fit with mating flanges, tend to introduce leakage and adversely affect the impedance match of the joint. Dents or scratches on any inside surface of an instrument should be avoided in order to maintain optimum performance from the unit.

Avoid inserting anything into the open end of the secondary guide which might damage the resistance card at the opposite end.

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

Model No.	*Frequency Range (Kmc)*	*Nominal Coupling (Db)*	*Transmission Line Rectangular Waveguide AN Type*	*Size (Inches)*	*AN Type Connectors*
306	2.6 - 4.0	30	RG-58/U	3 x 1-1/2 x 0.080	UG-214/U
544	2.6 - 4.0	40	RG-48/U	3 x 1-1/2 x 0.080	UG-214/U
545	2.6 - 4.0	50	RG-48/U	3 x 1-1/2 x 0.080	UG-214/U
233	4.0 - 6.0	24	RG-49/U	2 x 1 x 0.064	UG-149A/U
321	4.0 - 6.0	30	RG-49/U	2 x 1 x 0.064	UG-149A/U
322	4.0 - 6.0	40	RG-49/U	2 x 1 x 0.064	UG-149A/U
209	5.3 - 8.1	24	RG-50/U	1-1/2 x 3/4 x 0.064	UG-344/U
237	5.3 - 8.1	30	RG-50/U	1-1/2 x 3/4 x 0.064	UG-344/U
305	7.0 - 10.0	20	RG-51/U	1-1/4 x 5/8 x 0.064	UG-51/U
546	7.0 - 10.0	30	RG-51/U	1-1/4 x 5/8 x 0.064	UG-51/U
547	7.0 - 10.0	40	RG-51/U	1-1/4 x 5/8 x 0.064	UG-51/U
234	8.1 - 12.4	40	RG-52/U	1 x 1/2 x 0.050	UG-39/U
235	8.1 - 12.4	20	RG-52/U	1 x 1/2 x 0.050	UG-39/U
419	8.1 - 12.4	30	RG-52/U	1 x 1/2 x 0.050	UG-39/U
388	12.4 - 17.0	20	RG-91/U	45/64 x 25/64 x 0.040	UG-419/U
413A	18.0 - 26.5	20	RG-53/U	1/2 x 1/4 x 0.040	UG-595/U
414A	18.0 - 26.5	30	RG-53/U	1/2 x 1/4 x 0.040	UG-595/U
415	18.0 - 26.5	40	RG-53/U	1/2 x 1/4 x 0.040	UG-425/U
405A	26.5 - 36.0	20	RG-96/U	23/64 x 7/32 x 0.040	UG-599/U

PHYSICAL CHARACTERISTICS

Model No.	Overall Size (Inches) Length	Width	Height	Weight Lb - Oz
306	14	6-1/2	7	10 - 0
544	14	6-1/2	7	10 - 0
545	14	6-1/2	7	10 - 1
233	8-1/2	5	4-5/8	5 - 8
321	8-1/2	5	4-5/8	5 - 8
322	8-1/2	5	4-5/8	5 - 8
209	8-3/4	5-1/2	3-7/8	2 - 8
237	8-3/4	5-1/2	3-7/8	2 - 8
305	8	4-1/4	2-1/2	
546	8	4-1/4	2-1/2	
547	8	4-1/4	2-1/2	
234	6-1/8	4-3/8	2-1/8	1 - 0
235	6-1/8	4-3/8	2-1/8	1 - 0
419	6-1/8	4-3/8	2-1/8	1 - 0
388	4-1/4	2-7/8	2	0 - 8
413A	3	2	1-1/2	0 - 3
414A	3	2	1-1/2	0 - 3
415	3	2	1-1/2	0 - 3
405A	2-1/8	1-1/4	3/4	0 - 2

GENERAL CHARACTERISTICS (All Models)

Electrical

Coupling Variation . . . . . 3 db max. over entire band, except Model 234 which has 4 db max. variation

Calibration Accuracy . . . . . ±0.5 db at the measured calibration points from 2.6 to 36.0 kmc

Effective Directivity

Models rated at 30 db or more . . . . . 20 db min. over lower half of frequency range, decreasing to 15 db min. at the high frequency limit

Models rated at 20 and 24 db . . . . . 15 db min. over lower half of frequency range, decreasing to 10 db min. at the high frequency limit

Operational

Operating Temperature Range . . . . . -40° to +55° C

Humidity Effects . . . . . .Negligible

Physical

Finishes

Electrical Surfaces . . . . . High conductivity silver plate covered by corrosion-resistant rhodium

Non-conducting Surfaces . . . . . Black enamel

SERVICE AND REPAIR

Inquiries regarding the servicing, repair or operation of any Microline instrument should be directed to Field Service Engineering Department at the address below. Do not return any unit before making this contact.

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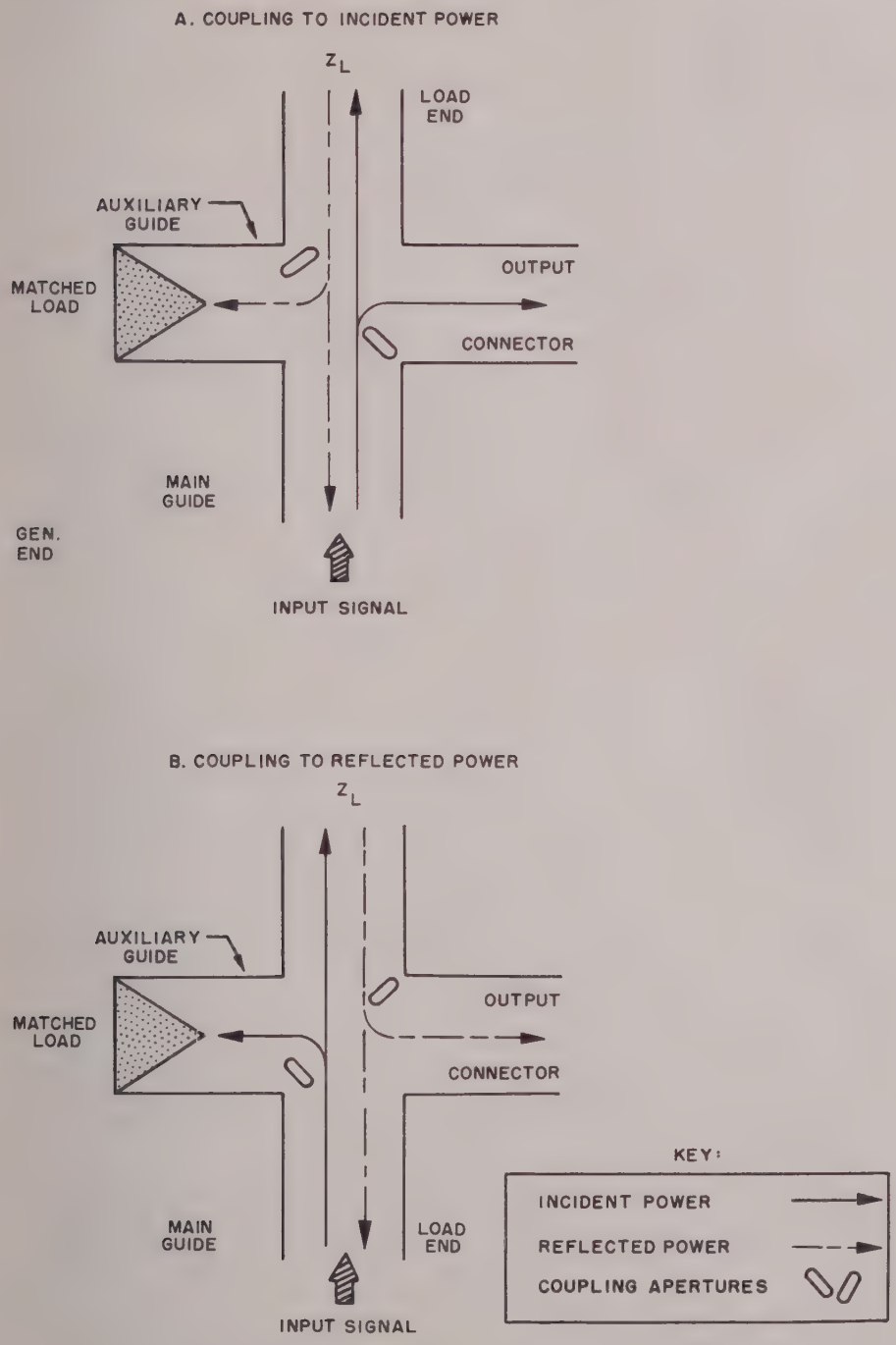


Figure 1. Simplified Operation of the Cross-Guide Directional Coupler

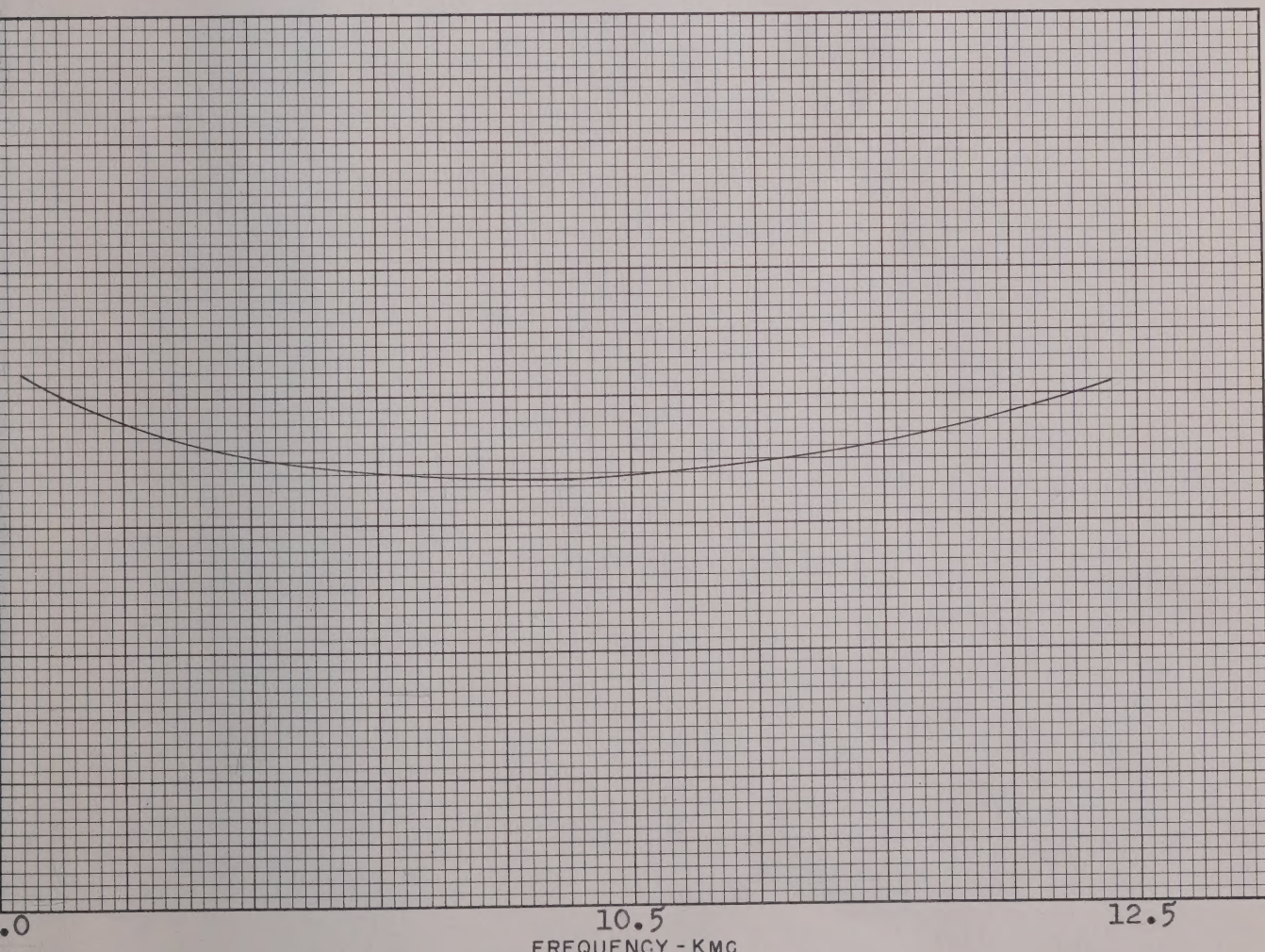
MICROLINE

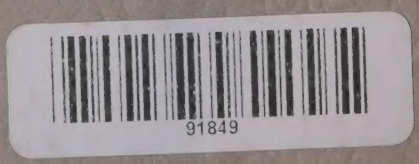
DIRECTIONAL COUPLER

MODEL 419

SERIAL #10

COUPLING VS FREQUENCY

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